PATTERNS IN THE LOCATIONS OF US MASS SHOOTINGS

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Bachelor of Science in Geography

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Stillwater, OK

2019

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
MASTER OF SCIENCE
July, 2019

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Date of Degree: July, 2019

Title of Study: PATTERNS IN THE LOCATIONS OF US MASS SHOOTINGS

Major Field: GEOGRAPHY

Abstract: Mass shootings are topics of intense public concern and debate. Unfortunately, most previous research examining mass shootings within the U.S. has focused on motivations or other characteristics of the shooter(s) with less attention directed at places or communities where the violence has occurred. This study explores mass shooting locations as unique sites marked by tragedy with the goal of revealing patterns associated with mass shooting locations. Such patterns may include county characteristics and the influence of state firearm policies. Two research questions are considered: 1) What county attributes are associated with locations where mass shootings have taken place? 2) To what extent are state firearm policies associated with the locations of mass shootings? Approximately 1,675 observations from the Gun Violence Archive (2014-18) are analyzed using logistic regression. All seven variables were found to be significant in predicting whether or not counties experienced mass shooting during the study period. The regression equation correctly predicted 78% of the counties and the model developed may be useful in predicting counties that might experience a mass shooting in the future.

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CHAPTER I

INTRODUCTION

When you hear the term mass shooting, what comes to mind first? Do you think of Sandy Hook Elementary in Newton, CT or the Mandalay Bay Hotel in Las Vegas, NV? These are places that experienced great tragedies felt by most Americans. Although tragedies of this scale are thankfully rare, few people realize that smaller mass shootings occur nearly every week.

It does not take a dozen or more people to be killed for an event to be considered a mass shooting. According to the Federal Bureau of Investigation (FBI), an event involving four people being shot or killed during a gun crime is classified as a mass shooting. Although some events receive extensive television and other media attention, other mass shootings attract little public notice. For lesser known tragedies, there are few candle light vigils or large memorial services. These events may not draw the eyes of the country and few people may ever know the names of the victims or the shooter. At the same time, the lives of families are quietly shattered.

If most people are not aware of the majority of mass shootings that occur, what are some of the characteristics of places that experience of mass shootings? This is the question that this study seeks to address. Nearly all research on mass shootings has focused on events that received extensive media coverage and are well known to the general public (Anisin 2016; Lankford

2012). This limits knowledge about the true number of incidences and does not give a representative view of the nature of mass shootings. A mass shooting falls under the category of mass murder but specifically refers to the perpetrator using a firearm (Gun Violence Archive 2019). While sometimes confused with spree killings, spree or serial murders occur in more than one location and/or at different times (Gun Violence Archive 2019).

Most previous research on mass shootings has focused on understanding the shooter while largely overlooking the community where the shootings take place. In his book *America's Landscape of Violence and Tragedy,* Ken Foote (1997) describes how the people who live near a mass murder want to know the motivation of the perpetrator and often place blame solely on the individual who committed the murders while at the same time absolving their own community. Foote argues that residents do not want to think that their community influenced people who commit heinous crimes. However, when studying other forms of crime, the community where they occur can be a vital source of information. Crime mapping is about understanding the locality and its influence on crime (Caplan 2011). For example, community characteristics such as income inequality and population affect the crimes that occur (Wang and Arnold 2008).

When a highly publicized mass shooting occurs, the national dialogue often focuses on mental health and the adequacy of gun laws. In addition, there is frequently debate about the principal cause of a mass shooting and what steps might be taken to help prevent future mass shootings. The connection between mass shootings and mental illness is a complicated one that many have attempted to explain (Metzl and MacLeish 2015). Although studies have been conducted on the impact of gun laws on firearm-related crime, the conclusions are often contradictory and offer no clear consensus (Kates and Polsby 2000; McDowall, Loftin, and Wiersema 1995).

Even when looking at the two well known mass shootings mentioned above, there are important differences. For example, the shooting in Newton, CT was at an elementary school and 20

children were murdered as well as six female teachers or administrators (Barron 2012). Newton, CT is a relatively small town with a population just over 27,000 (U.S. Census Bureau 2010). The shooting that occurred in Las Vegas, NV was at a concert and 59 people were killed ranging in age from 16 to 67 and an additional 441 people were injured by the shooter, not including those injured in the process of trying to escape (Gun Violence Archive 2019). In comparison to Newton with a population of only 27,000, Las Vegas has a population of over 640,000 and millions of annual visitors (LasVegasNevada.gov 2018). These two communities are vastly different and yet both suffered the trauma of a mass shooting. While it would be interesting to examine the cities or towns where mass shootings occur, most of the data is available at the county level and so this study will examine the counties that experienced a mass shooting.

FOCUS OF STUDY

Previous studies of mass shootings in the U.S. have focused on individual motivations and other characteristics of the shooter with less attention directed to the places or communities where shootings occurred. This study explores mass shooting locations as unique sites marked by tragedy with the goal of uncovering patterns in terms of county characteristics and the influence of firearm policies.

RESEARCH QUESTIONS

The first research question addresses the extent to which there are attributes common to counties where mass shootings take place. For example, what is the influence of income inequality, unemployment, and access to mental health? Research has shown that violent crimes tend to occur in lower income areas (Land, McCall and Cohen 1990). Therefore, this study will examine

if mass shootings occur more frequently in lower income counties. Likewise, areas with greater population density are more likely to experience violent crime than those with smaller population concentrations (Harries 2006). After a mass shooting, much of the national discourse focuses on the impact of mental health on mass shooters with some suggesting that improved access to mental health aid might help mitigate mass shootings (Metzl and MacLeish 2015). However, there has not been significant research to verify this. Therefore, access to mental health centers will be examined with respect to mass shooting locations.

The second research question will examine the influence of state firearm legislation on mass shooting locations. Every state in the U.S. has firearm legislation governing the use, sale, possession, and production of firearms. Some states maintain laws that seek to promote the safety of their citizens by restricting firearms, while others have laws that protect the rights of citizens to own and use their firearms. Five of the most common state laws are concerned with: 1) the right to carry firearms, 2) Stand Your Ground laws, 3) the Castle Doctrine, 4) reciprocity, and 5) the right to carry on college campuses.

The next chapter reviews some of the literature surrounding mass shootings and related topics. The following chapter outlines the methodology of this study and the fourth chapter shows the results and discussion for the logistic regression analysis.

CHAPTER II

REVIEW OF LITERATURE

Research suggests that most crime is concentrated in a relatively small percent of areas (Weinborn et al. 2017), meaning that there are vast tracts of land across the U.S. where no crime takes place. Given this fact, understanding what makes crime locations unique becomes important. If we can understand why people commit certain crimes in specific types of places, it may be possible to implement changes that will help prevent future crimes.

Crimes can be classified by their level of harmfulness. For example, assault is more harmful than petty theft, homicide is more harmful than assault, and mass shootings are more impactful than single homicides. Crimes that are more harmful to society should be treated differently when it comes to targeting and prevention (Weinborn et al. 2017). Crime Harm Indices have been developed to weight different kinds of crime based on their impact on society (Curtis-Ham and Walton 2017). Most analyses using a crime harm index do so within a small area such as in a city as a means of highlighting hot spots. However, this can also be done on a larger scale using census enumeration units (Curtis-Ham and Walton 2017).

Developing a definition for mass murder is difficult since there is little consensus within the literature. For example, Bowers, Holmes, and Rhom (2010) found that many studies have defined mass murder as incidents that occur at a single point in time with the number of victims varying from two to five with a median of four. While a mass shooting does fall under the category of

mass murder, it specifically refers to the perpetrator using a firearm (Gun Violence Archive 2019). The literature on mass murder mainly focuses on describing patterns involving the actual incidents. Bowers, Holmes, and Rhom (2010) note that location research is contradictory, citing four studies that come to different conclusions concerning about where mass murders are more likely to occur.

There are many misconceptions surrounding mass shootings. One belief is that they can be prevented if warning signs exhibited by the shooter are heeded sooner. However, this may not be feasible because mass murderers often share characteristics with a large portion of people who are not killers, making profiling difficult (Fox and DeLateur 2013). However, while efforts to prevent mass shootings may or may not be effective, it is still desirable to understand these events (Fox and DeLateur 2013).

A mass shooting is a subcategory of mass murder that specifies the use of a firearm. While there has not been as much research on mass shootings, there are multiple typologies of mass murder that have been proposed in previous research that are largely based on characteristics of the perpetrator and incident (Petee, Padgett, and York 1997). In the case of mass shootings, the focus is almost exclusively on the perpetrator, or shooter, with emphasis on the motivation of the perpetrator and how they committed the crime (Petee, Padgett, and York 1997). The typologies demonstrate a lack of consideration for the location of incidents beyond whether identifying if the event happened in a public or private place. This lack of consideration of the characteristics where mass shootings occur reveals a potential gap in our understanding of why such incidents happen.

A considerable body of research surrounding mass murders is also focused on the psychology of the perpetrator. One 1997 study found that murderers were often reported as exhibiting intense and uncontrollable hostility (Palermo 1997). Many of the people who commit these violent acts

do so out of feelings of outrage towards specific people or society as a whole. In some cases, the perpetrators want some form of retribution for injustices they feel that they have suffered (Palermo 1997). If a shooter has grievances that motivate his/her actions, it is logical to think that the choice of location may not be random. If locations are not random, there may be patterns that can be identified from other mass shootings.

Although it is not the focus of this study, understanding the motivations of mass shooters is of vital importance. Researchers ascribe many motivations to mass shooters that vary from the complex to the very simple. Some have examined and compared terrorists with rampage, workplace, and school shooters (Lankford 2012). One study found that instead of very complex and varying motives carried out in the murder of strangers, most mass murderers know their victims (Fox and Levin 1998).

Understanding trends in where firearm crimes occur is an important step in understanding mass shootings. Fox and Levin (1998) found that mass murders are more likely to happen in a rural area or small town compared to more populated areas such as cities. However, they also found that while the South has higher rates of homicide, mass murders are less common in the South (Fox and Levin 1998). A 2004 study looked at firearm related deaths from 1989-1999 in the context of urban versus rural counties (Branas et al. 2004). The study found that the counties that were the most urban had firearm homicide rates 1.90 times higher than the most rural counties, while the most rural counties had firearm suicide rates that were 1.54 times higher than the most urban counties (Branas et al. 2004).

Among other factors, the media has been shown to play a vital role in how the concept of mass shootings has evolved. For example, the media places significant emphasis on the most dramatic instances of mass shootings, causing the public to see them as typical examples (Duwe 2005). In reality, mass shootings that make national headlines are often atypical. It should be noted that the

social construction of mass murder has been shaped by news stories written for profit, since a priority of news agencies is to make money and sensational stories are typically more profitable (Duwe 2005). As a result, the general public often does not have an accurate perception of the true nature of mass shootings. Finally, a study on mass murders that have taken place throughout the twentieth century found that a significant portion of mass murders were familicides that did not occur in public places (Duwe 2004).

Even when talking about large mass shootings, some shootings have a greater impact than others. For example, the 2012 Sandy Hook Elementary School shooting in Newton, Connecticut changed perceptions within the American public about the nature of mass shootings (Shultz et al. 2013). School shootings, in particular, have a significant psychological impact not only for those directly involved, but on the community and nation as well. Sandy Hook was especially impactful because of the nature of persons affected and intense media coverage (Shultz et al. 2013). Since Sandy Hook, mass shootings have received greater coverage within U.S. media outlets. Some researchers suggested ways to help prevent school shootings by studying the characteristics of schools where mass shootings occurred and have suggested strategies based on their findings (Wike and Fraser 2009). In 2009, Kleck studied arguments in favor of gun control following mass shootings in schools. His research was aimed at three questions: 1) Do shooters get their firearms from gun shows? 2) What is the extent to which large magazines impact how many people are killed? and 3) Would banning all or certain guns help prevent mass shootings? (Kleck 2009).

In cases when mass shooters have a severe mental illness, media coverage often generates other types of unfortunate effects. For example, media coverage can foster negative attitudes towards people with severe mental illnesses because of how they are portrayed (McGinty, Webster, and Barry 2013). One group of researchers conducted a random survey and evaluated opinions after exposing participants to news stories about a mass shooting perpetrated by a mentally ill person and found that such stories increased the negative attitudes that the participants had towards

people who have a serious mental illness (McGinty, Webster, and Barry 2013). McGinty, Webster, and Barry note how there is a decrease in treatment rates for mental illness when public opinion is negative. This is unfortunate since access to mental health services is a vital component in preventing recidivism in people with psychotic disorders (Lamberti 2007).

There is also debate over the relationship between mental illness and mass shootings. While not all mass murderers are mentally ill, mental illness is more common among mass shooters than within the rest of society (Fox and Fridel 2016). Fox and Fridel note that additional gun limitations targeting people with diagnosed mental illness are unlikely to impact mass shooters and may lead to others not seeking help. Mass shootings are often used by gun control advocates to lobby for more restrictions (Fox and Fridel 2016). Such findings suggest that the issues surrounding mass shootings are more complex than simply connecting them to mental illness and gun control (Metzl and MacLeish 2015). Emotionally charged events such as mass shootings should not be written off as a simple happenstance, since larger societal issues may be masked by gun control and mental illness advocacy after mass shootings (Metzl and MacLeish 2015).

There is a common belief that the increasing availability of firearms causes an increase in homicides. For example, one study explores correlations between homicide rates and the distribution of firearms between the 1940s and 2000 (Kates and Polsby 2000). Kates and Polsby found that while firearms and homicide rates are sometimes associated, there is not a strong correlation between the two (Kates and Polsby 2000). Another way to examine the impact of firearms on homicide rates is to look at places that have recently changed their laws concerning firearms. Researchers conducted a study of five metropolitan areas that several years before had changed their right to carry laws to make it easier for people to obtain firearm carry permits (McDowall, Loftin and Wiersema 1995). They examined homicide rates before and after the laws changed to see the impact. In three of the five cities there was a statistically significant increase in homicide rates. While the researchers could not definitively say that the changes in the law

caused an increase in firearm homicides, they did conclude that they did not cause a decrease (McDowall, Loftin and Wiersema 1995). One significant limitation is that they only looked at five study areas, making it difficult to draw conclusions or make useful extrapolations.

The right of an individual to carry a concealed firearm is a very contentious topic, especially following a mass shooting. *Right to carry* refers to whether an individual has the legal right to carry a firearm on their person for the purpose of defense. Some states include in their constitution provisions stating that individuals have the right to carry without the need for a license. Other states require a license and allow a person to "open" or conceal carry. Conceal carry is generally considered to be when a person is carrying a firearm that others cannot readily see, whereas open carry allows a person to carry a visible firearm. Another group of states require a license and only allow a person to conceal carry. The last group of states do not allow an average person to carry a firearm on their person with or without a permit. In most states there are exceptions, but these are the general laws. Concerning mass shootings, one study found that *right to carry* laws neither increase or decrease with any significance the extent to which mass shootings occur (Duwe, Kovandzic, and Moody 2002). However, it is noted that such findings do not suggest that right to carry laws have no influence on where a shooter chooses to commit a violent act (Duwe, Kovandzic, and Moody 2002). One strong limitation to their study is that it only looked at whether a state was issuing a permit to carry or not and did not take into account the many laws affiliated with the right to carry that vary among states.

Stand Your Ground laws address the legal right of a person to either remain where they are and defend themselves when threatened or the legal need to attempt to retreat to a safe location without using lethal force against a threat (NCSL 2017). *The Castle Doctrine* is a principle that defends the right of an individual to use reasonable force against a home intruder in order to protect himself/herself that can include deadly force (NCSL 2017). In general, states that have

enacted the Castle Doctrine are considered more permissive because this doctrine is meant to protect the rights of firearm owners.

Reciprocity refers to a practice defining whether or not a state considers a permit to carry a firearm from another state to be valid within their own borders (Hudson 2017). There are varying levels of reciprocity among states that range from no reciprocity with any states to full recognition of all states' permits. In general, states that recognize all permits are considered more permissive and states that do not reciprocate with any state are considered more restrictive.

College campus carry laws refer to whether or not individuals are allowed to carry a personal firearm on a college campus. A few states allow an individual to carry a firearm on all public campuses, provided they follow all other firearm regulations of that state. Some states allow each school to make decisions about permitting campus carry. Many states do not allow any campus carry or only permit firearms on campus if they are stored in a vehicle.

Studies have used regression to analyze mass shootings with mixed results. Anisin (2016) looked at the interaction between mental illness, gun ownership, and mass shootings across six variables with the objective of determining if any were useful in predicting mass murders or the number of people killed. Findings from this study demonstrate that regression analysis may not be useful in identifying causation because of the complexity of mass shootings. Four of the six variables were concerned with the shooter, while the other two addressed state gun ownership and gun laws (Anisin 2016). No studies appear to look exclusively at variables unrelated to the shooter. By taking the shooter out of the equation, it is possible that other patterns may emerge.

Given that studies have shown mass murders are often linked, one of the most troubling elements of mass shootings is the anticipation of another. One study found that there is an increased probability of similar incidents for 13 days after a mass shooting or school shooting (Towers et al. 2015). The concept of predictive policing uses historical data to create a forecast of where and

when crime is likely to occur so police resources can be used more effectively (Rummens, Hardyns, and Pauwels 2017). Likewise, previous research has found that homicide rates are not completely random in their distribution (Baller, Anselin, Messner, Deane and Hawkins 2001). Rather, homicides exhibit significant spatial autocorrelation that is not fully explained by similarities among communities. However, there can sometimes be vast differences in the crime rates between adjacent areas that are difficult to explain (Harries 2005).

CHAPTER III

METHODOLOGY

Previous studies of mass shootings in the U.S. have focused on individual motivations and other characteristics of the shooter with less attention directed to the places or communities where shootings have occurred. This study explores mass shooting locations as unique sites marked by tragedy with the goal of revealing patterns in terms of county characteristics and state firearm policies.

Data about mass shootings comes from the Gun Violence Archive (GVA), a database created in 2012 by an independent research group that includes extensive data on gun violence (Gun Violence Archive 2019). The GVA catalogues various types of firearm-related crime including mass shooting events going as far back as 2014 and using the FBI's definition of mass shootings: "four or more shot and/or killed in a single event [incident], at the same general time and location, not including the shooter" (Gun Violence Archive 2019). Since this is the definition used in data collection, it is also used for this study. During the initial part of this research, only data from 2014-16 was available, but eventually 2017 and 2018 mass shootings were added to the analysis. Figure 1 shows the spatial distribution of mass shootings that occurred between 2014 and 2018. There is clearly a spatial pattern to the mass shootings that appears to follow population. For example, the less populous western and plains states did not experience as many

mass shootings as within the eastern half of the country. There are also obvious clusters of mass shootings in major cities such as San Francisco, Sacramento, and New York City. Such clusters within highly populated areas make it necessary to normalize by population.

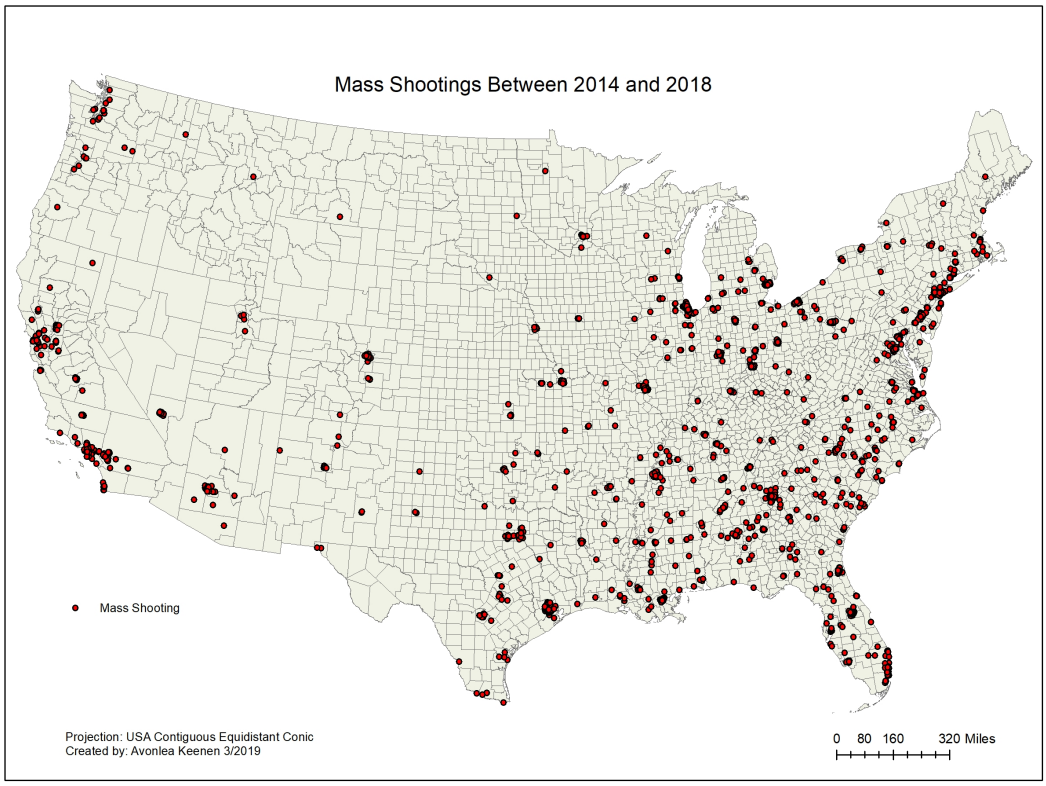

Figure 1. All 1,675 mass shooting locations from 2014-2018.

Data representing: 1) the percent of the population that is white, 2) the percent of housing units that are vacant, 3) the percent of the population that is unemployed, and 4) income inequality of the counties where mass shootings have occurred, comes from the 2012-2016 American Community Survey estimates. The Census estimates income inequality using the Gini Index, which is a summary statistic that measures income dispersion within a given geographic area (U.S. Census Bureau 2016). The Gini Index is a more applicable statistic than just average income because it highlights communities that are experiencing inequality in income dispersion. Researchers have used the Gini Index to predict homicide rates on both cross-national and sub-national scales. One such study (Daley, Wilson and Vasdev 2001) found that within Canada, the

Gini Index is positively correlated with homicide rates. Additional research by Daley, Wilson and Vasdev examining homicide rates within the U.S. from 1990 found that the Gini Index was highly correlated with homicide rates, whereas median household income was not (2001). Finally, they found that income inequality is a significant contributor to homicide rates. Following their study, this thesis uses the Gini Index instead of median or average household income.

Data about the availability of mental health services was obtained from the Substance Abuse and Mental Health Services Administration with the Center for Disease Control (Behavioral Health Treatment Services Locator 2018). This source includes a comprehensive list of medical providers that deliver mental health services in every U.S. county. Once there was a list of unique counties that had experienced a mass shooting from 2014-2018, the number of mental health centers within each county was determined using the Substance Abuse and Mental Health Services Administration's Behavioral Health Treatment Service's Locator.

The first component in this study was to compile descriptive statistics of mass shootings between 2014 and 2018. This includes the average number of people shot or killed during a mass shooting by year, month, and state. Characteristics of counties that experienced a mass shooting were compared to demographic attributes corresponding to an equal number of random counties that did not experience a mass shooting during the study period. Several analysis tools, such as a spatial ellipse which shows directional movement of phenomenon, were used to reveal general trends tied to mass shootings across the United States (Chainey, Tompson, and Uhlig 2008). The most time-consuming part of this step was collecting data for all of the counties where a mass shooting took place. Each observation includes pertinent firearm laws, the number of mental health centers per county, a latitude and longitude centroid, and demographic data.

Data	Data Type	Description	Source
Mass Shootings	Nominal data	Presence or absence of a mass shooting in a county	Gun Violence Archive
Gini Index	Ratio data	The Gini Index measures income inequality	US Census
Population Per Mental Health Center	Ratio data	Number of people per mental health center in a county	SAMHSA
Percent White	Ratio data	Percent of the population in a county that is Caucasian	US Census
Percent Vacant	Ratio Data	Percent of houses in a county that are vacant	US Census
Percent Unemployed	Ratio Data	Percent of population unemployed	US Census
Law Rank 17-20	Nominal Data	Whether or not a county has a law rank from 17-20	See Appendix
Law Rank 5-8	Nominal Data	Whether or not a county has a law rank from 5-8	See Appendix

Table 1. Description of variables for analysis.

RESEARCH QUESTION 1

The first research question explores county attributes common to locations that have experienced mass shootings. Gathering pertinent data was the most time-consuming task in preparing to address this question. For this analysis, demographic data was aggregated to the county level. Chainey, Thompson, and Uhlig (2008) note that it can be useful to aggregate crime points to larger geographic units for analysis. It is also noted that larger geographic units, such as counties, can be linked to other sources of data, making it easier to create thematic maps (Chainey, Thompson, and Uhlig 2008).

Data about mass shootings came from the Gun Violence Archive and contained the incident date, state, city or county, address, the number of people injured, and the number of people killed for each event. During the initial part of this research, only data from 2014-16 was available, but

eventually 2017 and 2018 mass shootings were added to the analysis. In order to obtain latitude and longitude for each mass shooting, all 1,675 individual incident reports from 2014-2018 were examined. There were a few reports that did not include a geolocation. For those, an address was used with Google Maps to obtain latitude and longitude. Because this research focused primarily on the continental U.S., the one mass shooting that occurred in Alaska during the study period was excluded. Also, there were no mass shootings in Hawaii from 2014-2018. For the analysis, this study treated Washington D.C. as both a state and county since there were mass shootings within the District of Columbia during the study period. Subsequently, mass shooting locations were added to ESRI's ArcMap and joined to a shapefile of all US counties to determine counties that had experienced a mass shooting.

Once there was a list of the 451 unique counties that experienced a mass shooting from 2014-2018, the number of mental health centers in each county was determined using the CDC's treatment locator. To each of the unique counties demographic data was joined from the US Census. This list of variables included the percent of the population that is white, the percent of the population that is unemployed, the percent of housing units that are vacant, and the Gini Index value (see Table 1). This research also used the county population for some of the initial analysis and to normalize variables.

After some preliminary analysis, it was necessary to adjust several of the variables to obtain relevant results. Instead of using the number of mental health centers, the data was normalized by dividing the total population of the county by the number of mental health centers. This provided the number of people per mental health center in a given county. In the initial regression models, the law rank variable came back as insignificant. In order to determine if manipulating the variable might lead to different results two dummy variables were used. The first dummy variable designated whether or not a county has a law rank between 5-8, while the second showed whether or not a county has a law rank between 17-20. These variables are used to reveal if it is

statistically significant whether a county has either very restrictive or very permissive firearm legislation. Figure 2 shows which states have law ranks between either 5-8 or 17-20.

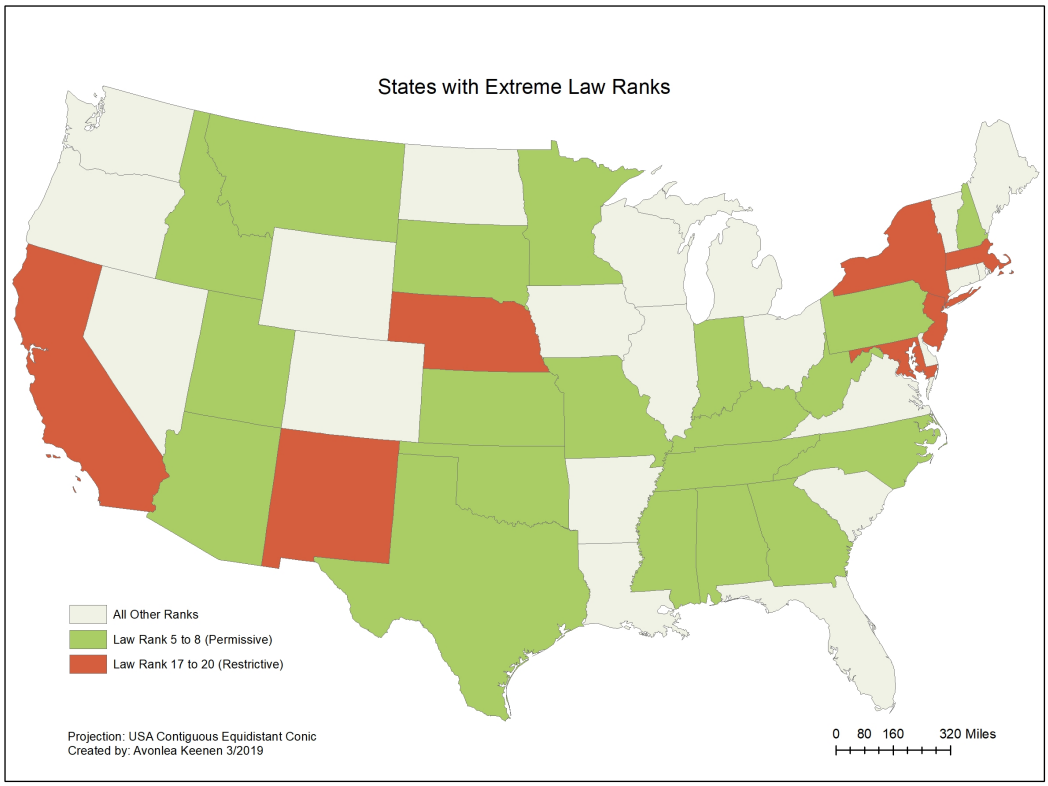

Figure 2. Extreme law ranks used in logistic regression analysis.

RESEARCH QUESTION 2

The second research question examines the impact of state policies on mass shooting locations. For the second research question, U.S. states were divided into four categories based on firearm laws: 1) permissive, 2) moderately permissive, 3) moderately restrictive, and 4) restrictive (see Table 2). Each state was placed in a category based on how it scored on five key themes: 1) the right to carry, 2) Stand Your Ground laws, 3) the Castle Doctrine, 4) reciprocity, and 5) the right to carry on college campuses. Table 2 displays laws pertaining to each theme and the category of state they apply to. Each state received a score based on their firearm laws using a range

extending from 5 to 20. In Figure 3, the states were divided into 5 classes using Jenks Natural Breaks to determine the intervals: 5.0-7.0 is permissive, 7.5-10.0 is moderately permissive, 10.5-14.5 is the middle class, 15.0-18.0 is moderately restrictive, and 18.5-20.0 is restrictive. Data corresponding to various firearm laws came from multiple sources (see Appendix I). Figure 3 shows the states according to their law ranks.

	Permissive (1)	**Moderately Permissive (2)**	**Moderately Restrictive (3)**	**Restrictive (4)**
Right to Carry	Constitutional Carry or Open Carry	Conceal Carry	May Issue or Very Limited	No Right to Carry
Stand Your Ground	Stand	No law **(2.5)**	No law **(2.5)**	Retreat
Castle Doctrine	Enacted			Not Enacted
Reciprocity	Recognition	True Reciprocity	Conditional Reciprocity	No Reciprocity or Recognition
College Campus Carry	All Public Campuses	School Chooses	In Vehicle Only	No Campus Carry

Table 2. Method for state classification based on legislation.

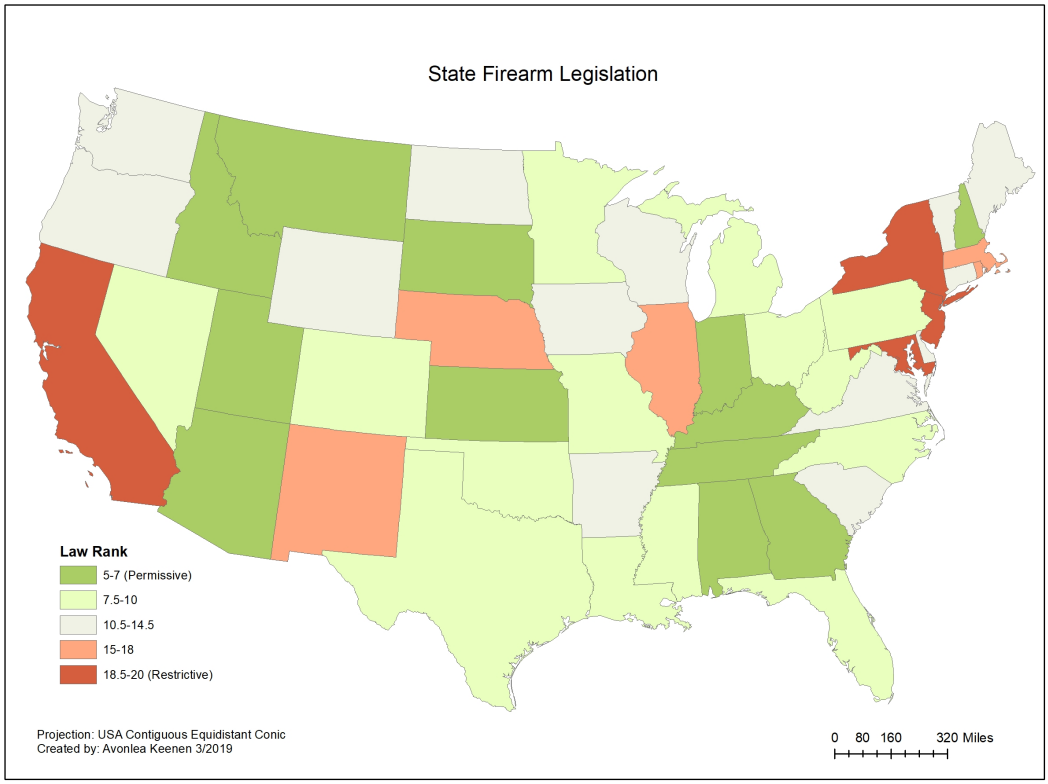

Figure 3. Law ranks for each State.

ANALYSIS OF RESEARCH QUESTIONS 1 AND 2

The first research question examines the extent to which there are county attributes common to locations that experience mass shootings, while the second examines the impact of state policies on mass shooting locations. To evaluate Research Questions 1 and 2, this study applied a logistic regression analysis using the demographic variables detailed in Table 1 as independent variables. One limitation of regression is that it assumes observations are independent (Duwe, Kovandzic, and Moody 2002). However, as previously noted, some of the literature suggests that this is not the case because a mass shooting can trigger subsequent mass shootings in the near future (Towers et al. 2015). In order to address this limitation, this research applied a regression at the county level only. By coding the dependent variable 1 or 0 as whether or not a county

experienced a mass shooting, and not the number of mass shootings, the goal was to avoid the influence of spatially clustered mass shootings triggered by an initial incident.

In order to make this method viable, an equal number of randomly selected control counties were used where a mass shooting did not take placed between 2014 and 2018. One limitation of this method is that the randomly selected counties might have experienced a mass shooting outside of the study period. To obtain the random counties, this study first identified all counties in the U.S. that did not experience a mass shooting and then assigned a random number ranging from 0-1 to the fourth decimal using the field calculator in ArcMap. 451 counties were then selected to match the number that experienced a mass shooting. For each of these random counties the research determined: 1) the number of mental health centers, 2) the firearm legislation rank, and 3) other demographic data matching what was collected for counties that experienced a mass shooting. Just as with the mass shooting data, the random counties were limited to the continental U.S. Figure 4 shows the counties that experienced a mass shooting between 2014 and 2018 in red and randomly selected counties that did not experience a mass shooting during the study period in blue.

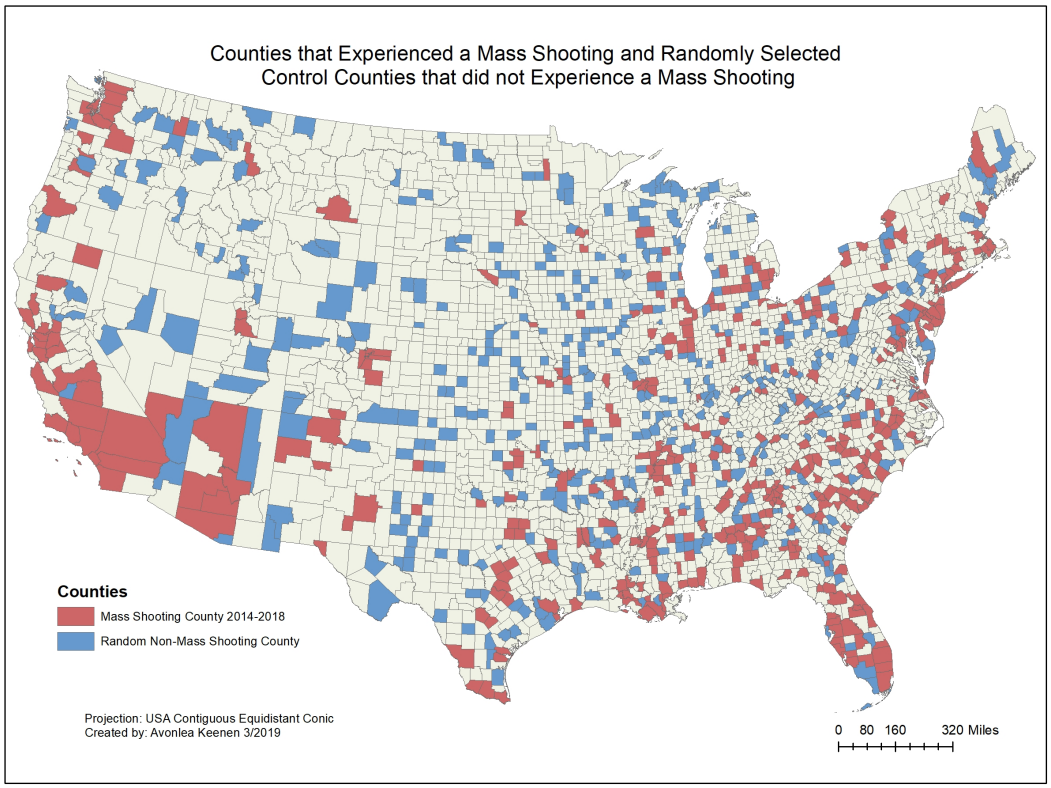

Figure 4. Counties used in logistic regression analysis.

The null hypothesis is that there is no relationship between mass shootings and a county's demographic characteristics, the population per mental health center, and firearm legislation. The acceptable alpha significance level was set at 0.10. Before beginning the logistic regression analysis, it was necessary to evaluate multicollinearity issues between the independent variables using SPSS. The study then applied a logistic regression and evaluated the significance of the model, the percent of counties predicted correctly, and the significance of the coefficients of each independent variable. After obtaining the regression equation, the coefficients of the independent variables were interpreted in terms of the dependent variable.

The product of the regression analysis for Research Questions 1 and 2 is a regression equation. This equation shows how each of the significant variables is associated with whether or not a county experienced a mass shooting in the population sample. With the regression equation, data was used from all counties that did not experience a mass shooting during the study period to

determine their probability of experiencing a mass shooting. A map was created that shows these counties and whether or not they fall within the criteria of being more or less likely to experience a mass shooting.

CHAPTER IV

RESULTS/DISCUSSION

The first part of this analysis includes a report that presents descriptive statistics. Table 3 shows some of the summary statistics for mass shootings divided by year. The year with the most mass shootings within the study period (383) was 2016. In contrast, 2014 had the fewest with 273. All of the years except 2016 had, on average, four people injured per mass shooting, while 2016 had an average of 5.2. For all five years, the average number of people killed was slightly more than one. These averages are very different from what many people perceive as being associated with a typical mass shooting since they are not the type of mass shootings that the media usually covers (Duwe 2005). Across the five-year study period, 7,115 people were injured and 1,897 killed in mass shootings. These statistics help to illustrate the magnitude of direct and indirect impacts to families.

There are a few outliers in the Gun Violence Archive dataset during the study period that include mass shootings having a larger number of injured or killed. In 2014 and 2015 there were no major outliers, but in 2016 on June 12 there was a mass shooting in Orlando, FL that resulted in 50 people killed and 53 injured. On July 1, 2017 there was a mass shooting in Little Rock, AR that left 25 people injured but none killed. On October 1, 2017, the well-publicized Las Vegas shooting happened injuring 441 and killing 59. This was the largest outlier during the study

period. The last major outlier during 2017 happened on November 5th in Sutherland Springs, TX leaving 27 people dead and 20 injured. There were no major outliers during 2018. The outliers mentioned above all had 20 or more people who were either injured or killed.

	Total Number of Mass Shootings	Average Injured	Average Killed	Total Injured	Total Killed
2014	273	4.0	1.0	1,100	264
2015	333	4.0	1.1	1,328	367
2016	383	4.0	1.2	1,537	456
2017	346	5.2	1.3	1,803	437
2018	340	4.0	1.1	1,347	373
Total	1,675	4.2	1.1	7,115	1,897

Table 3. Mass shootings within the study sample.

Figure 5 shows the number of mass shootings by month for each of the five years. The data reveals a distinct peak during the summer months of June, July, and August which corroborates with previous research into the seasonality of crime and how the summer months tend to have higher crime rates (Ranson 2014). The highest count occurred in June of 2018 with 51 mass shootings and the lowest number was in January of 2016 with just 11. For all of the years, July had the greatest number of mass shootings with 208 and a five-year average of 41.6. March had the lowest average at 19.4 and the lowest total number of mass shootings at 97 for the five years. Although it is difficult to determine a specific reason for the distinct increase in mass shootings during the summer months, this trend does follow the peak found in other criminal activity when temperature increases (Ranson 2014). By acknowledging the increased risk indicated by the data, community leaders or legislators could potentially implement preventative measures during the summer.

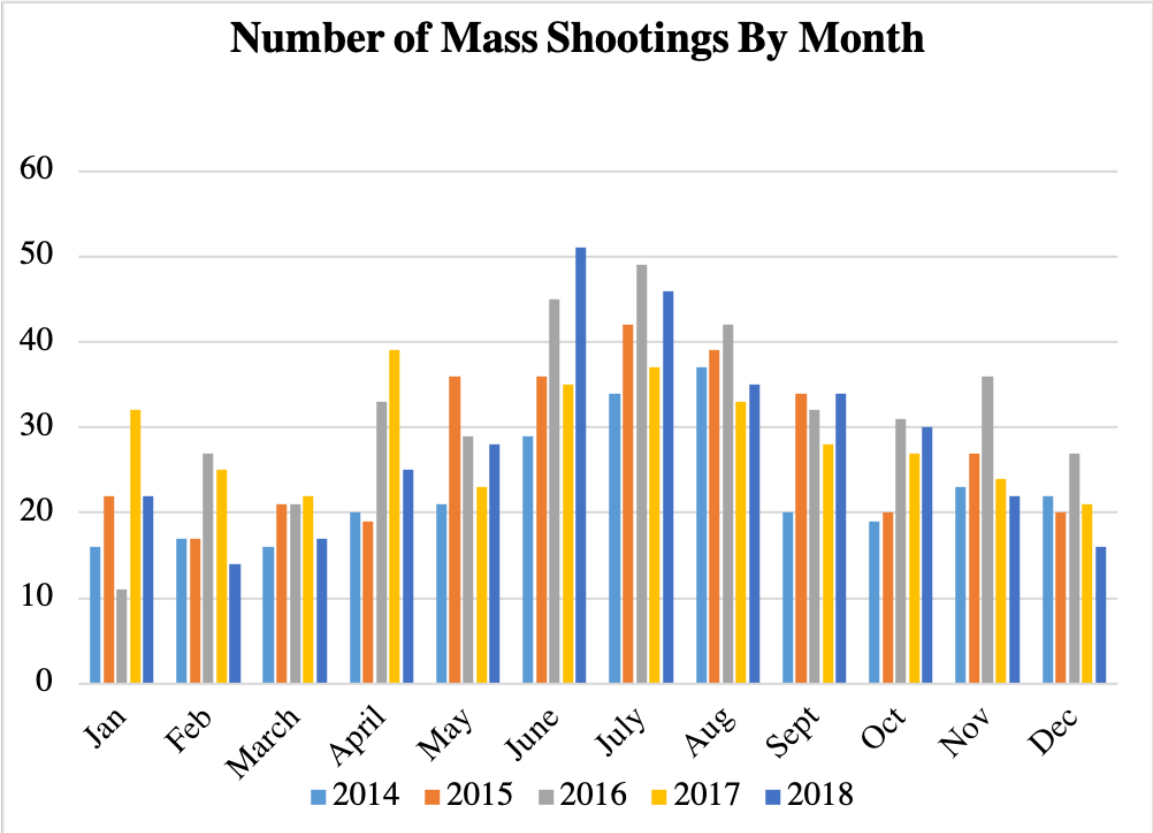

Figure 5. Mass shootings divided by year and month.

Figure 6 shows the directional distribution of the mass shooting locations divided by year. The black ellipse represents the distribution of counties weighted by total population. There is not much variation between any of the spatial ellipses. Since the total population ellipse is so similar to the mass shooting ellipses, we can infer that population influences the distribution of mass shooting locations. This is consistent with a visual analysis of the data as shown in Figure 1 and confirms other portions of the analysis. Although there are other factors that may influence mass shootings, there is a higher risk where there are more people.

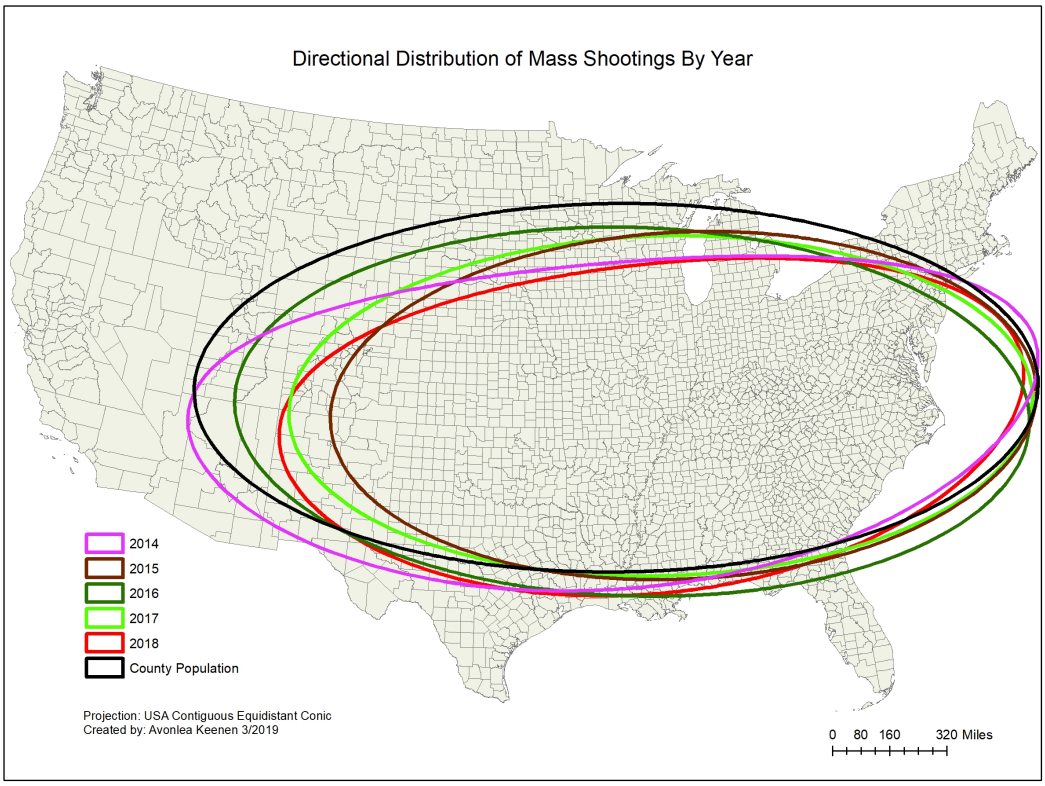

Figure 6. Spatial ellipses showing directional trends of mass shootings.

Table 4 shows the number of mass shootings by state for each year as well as the number of mass shootings per 100,000 people for that state. With its large population, California has the largest number of mass shootings at 191, however the District of Columbia has the highest rate of mass shootings at 3.822 per 100,000 people. There are only three other states that have mass shooting rates above one per 100,000 people: Louisiana at 1.478, Illinois at 1.278, and Tennessee at 1.072. During the study period Hawaii, Idaho, New Hampshire, North Dakota, and Wyoming did not experience any mass shootings. The one mass shooting in Alaska is shown in Table 4, although it was not included in other portions of the analysis since it is not part of the continental US. Table 4 is color coded based on each state's firearm laws: dark red is restrictive, light red is moderately restrictive, gray is a middle category, light green is moderately permissive, and dark green is permissive. Four of the five states with the most restrictive firearm laws are in the top half of the

ranking and the fifth state, New York, is 27th. States that have permissive firearm legislation are more evenly distributed throughout the rankings.

	2014	2015	2016	2017	2018	Total	Mass Shootings Per 100,000 People
District of Columbia	5	2	5	5	6	23	3.822
Louisiana	12	14	13	15	13	67	1.478
Illinois	26	25	42	36	35	164	1.278
Tennessee	13	11	12	14	18	68	1.072
Mississippi	4	2	6	13	3	28	0.944
Missouri	8	12	10	10	14	54	0.902
Alabama	2	4	15	7	14	42	0.879
Maryland	2	13	11	8	9	43	0.745
Georgia	18	20	17	9	8	72	0.743
South Carolina	7	11	5	7	4	34	0.735
Florida	16	25	30	24	30	125	0.665
Indiana	8	10	8	7	8	41	0.632
Delaware	0	1	2	1	1	5	0.557
Ohio	7	14	11	21	11	64	0.555
Arkansas	2	2	3	3	6	16	0.549
New Jersey	6	9	9	13	10	47	0.535
New Mexico	1	2	4	2	2	11	0.534
Pennsylvania	8	15	10	15	19	67	0.527
Nevada	4	1	3	2	4	14	0.518
Michigan	13	11	11	8	8	51	0.516
California	45	27	47	37	35	191	0.513
Virginia	8	5	11	12	4	40	0.500
Kentucky	4	4	2	6	4	20	0.461
North Carolina	3	12	9	7	11	42	0.440
Kansas	0	1	5	4	2	12	0.421
Texas	14	19	31	22	16	102	0.406
New York	14	21	15	13	13	76	0.392
Colorado	2	3	4	2	8	19	0.378
Connecticut	1	2	6	2	2	13	0.364
Oklahoma	2	4	1	1	5	13	0.347
Minnesota	1	5	5	4	3	18	0.339
Nebraska	0	3	0	0	3	6	0.329
Arizona	1	6	4	5	2	18	0.282
Washington	3	1	8	3	3	18	0.268
South Dakota	1	1	0	0	0	2	0.246
Wisconsin	2	3	2	2	4	13	0.229
Massachusetts	4	5	3	1	1	14	0.214
Montana	0	1	0	1	0	2	0.202
Rhode Island	1	1	0	0	0	2	0.190
Vermont	0	1	0	0	0	1	0.160
Oregon	2	2	2	0	0	6	0.157
Maine	1	0	0	1	0	2	0.151
Utah	2	0	0	1	1	4	0.145
Alaska	1	0	0	0	0	1	0.141

Iowa	0	2	0	2	0	4	0.131
West Virginia	0	0	1	0	0	1	0.054
Hawaii	0	0	0	0	0	0	0
Idaho	0	0	0	0	0	0	0
New Hampshire	0	0	0	0	0	0	0
North Dakota	0	0	0	0	0	0	0
Wyoming	0	0	0	0	0	0	0

Table 4. The number of mass shootings per state.

Table 5 shows a comparison of the independent variables between the two groups of counties. The first variable is the average number of people per mental health center for counties that had at least one mental health center. Those counties that did not have a mental health center were assigned a value of zero and were not included in the average because it would have skewed the data. For counties that did not experience a mass shooting there were 137 counties that have no mental health centers and 37 counties that did experience a mass shooting but do not have a mental health center. For counties that experienced a mass shooting between 2014 and 2018, there is, on average, nearly twice as many people per mental health center compared to counties that did not experience a mass shooting during the study period. However, the raw numbers show that counties that experienced a mass shooting have, on average, 10.9 mental health centers compared to two for the random counties. This is likely because of a difference in population among the counties. The counties that have a higher population have more mass shootings and are likely to have more mental health centers. However, even though they have a higher number of mental health centers, there are more people per center.

Three of the independent variables are percentages describing various demographic characteristics of the population. The average percent of the population that is unemployed was 1.4% higher for mass shooting counties at 8.3%. The average percent of the population that is white was 16.4% lower than counties that did not experience a mass shooting which averaged 86.3%. For the percent of housing units that are vacant, the average for mass shooting counties was 6% lower at 13.1% compared to the non-mass shooting counties at 19.1%. On average,

	Mass Shooting Counties 2014-18	Random Non-Mass Shooting Counties
Average Population per Mental Health Center >0	43,584	22,831
Average Number of Mental Health Centers	10.9	2
Average Percent of Population Unemployed	8.3%	6.9%
Average Percent of Population that is White	69.9%	86.3%
Average Percent of Housing Units Vacant	13.1%	19.1%
Average Gini Index Value	0.4624	0.4431
Most Common Law Rank	8	8
Number of Counties with Law Ranks between 5-8	211	247
Number of Counties with Law Ranks between 17-20	70	35

Table 5. Comparison of variables.

counties that experienced a mass shooting from 2014-2018 tend to have higher unemployment, a lower percentage of the population that is white, and fewer vacant housing units compared to randomly selected counties that did not experience a mass shooting.

Ranging from one to zero, the Gini Index is used to indicate income inequality across a county. For the Gini Index, a value of 0 indicates perfect equality and a value of 1 means perfect inequality. Analysis of the data revealed a 0.0193 difference between counties that experienced a mass shooting and the random control counties, with mass shooting counties having a slightly higher value. This suggests that mass shooting counties have slightly more income inequality.

Research Question Two focused on firearm legislation with three related variables. Law ranks between 5-8 are on the more permissive end of the firearm legislation spectrum, while ranks between 17-20 are on the more restrictive end. The most common law rank for both the mass shooting and the random non-mass shooting counties was eight. For counties that experienced a mass shooting there are 106 with a law rank of eight, and 124 random counties with a law rank of eight. There are 211 mass shooting counties that have a law rank between 5-8, whereas 247 of the

random counties have ranks between 5-8. Of the counties that have law ranks between 17-20, there are 70 mass shooting counties and only 35 random counties.

For the counties that experienced a mass shooting during the study period, there were fewer with permissive firearm legislation than the random counties and nearly twice as many counties with restrictive legislation in comparison to the non-mass shooting counties. There is a large difference between the number of counties with law ranks of 5-8 and 17-20 in both counties that did and did not experience a mass shooting. In order to isolate the most restrictive and permissive counties, the three most restrictive and permissive law ranks were used to create these variables. The permissive variable included the most common law rank of eight which resulted in a much higher number of counties falling in that category. The study did not only include the two most permissive and restrictive law ranks, because that caused there to be too few counties within the restrictive end to be significant.

Before running a regression analysis, it was important to consider multicollinearity issues that might be present among the independent variables. By running bivariate correlations on all of the independent variables, it was possible to determine if any of the variables were closely related and needed to be discarded. There were several significant correlations between the independent variables, but the highest Pearson's *r* was only -0.505 between the percent of the population that is white and the percent of the population that is unemployed. The percent of housing units that are vacant, the Gini Index, the percent of the population that is white, and the percent unemployed all correlated significantly with each other. This is not surprising because they are related statistics, but with the exception of percent white and unemployed, all of the Pearson's *r* values were less than 0.5 and most much less than that.

The law rank variable between 5-8, significantly correlated with the other law rank variable for counties with ranks between 17-20. This is not surprising because they are essentially describing

the same thing but on different extremes. Both of these variables had significant correlations with total population. Although total population is not one of the variables used in the logistic regression analysis, it was included in the correlations to better describe the variables. Law ranks between 5-8 had a negative Pearson's *r* of -0.158 and law ranks between 17-20 had a Pearson's *r* of 0.288 with total population. These are both relatively low correlation scores, but do show that as total population increases, so does the likelihood of that county having restrictive firearm legislation. The population per mental health center was significantly correlated with the percent of housing units that are vacant, the Gini Index, the percent of the population that is white, and the percent unemployed. However, the highest Pearson's *r* was only -0.235 with percent of housing units that are vacant. As expected, this variable also correlated with total population since the variable is normalized by population.

RESEARCH QUESTIONS 1 AND 2

In contrast to linear regression, interpreting the pseudo R-squared in logistic regression is more difficult. For Research Questions 1 and 2, the binary logistic regression returned an R-squared of 0.492, which indicates that 49% of the variability in the data set can be explained by the independent variables. That being said, the regression equation correctly predicted whether or not a county in the data set experienced a mass shooting 78.8% of the time, which indicates a better model fit. For the counties that did not experience a mass shooting, the model predicted 80% correctly. For the mass shooting counties, the model correctly predicted 77.6%.

Of the seven variables, six were significant at the 0.1 alpha level with the exception of a dummy variable showing whether a county had a law rank between 17-20. However even though the variable did not achieve the 0.1 alpha level, it was very close at 0.176. Since it was so close to the alpha level, it was included in the discussion to add further explanatory power to the regression

equation. The population per mental health center, the percent of the population that is unemployed, and the Gini index all have positive coefficients. This means that as these variables increase so do the odds of a county experiencing a mass shooting. The percent of the population that is white and the percent of housing units that are vacant have negative coefficients. As these variables increase, the odds of a county experiencing a mass shooting decrease. The two law rank variables are categorical with only two possible values: 1 if a county falls within the law rank range and 0 if it does not. The coefficient of the variable for law ranks between 17-20 is positive which means counties with more restrictive firearm legislation are more likely to have a mass shooting. In comparison, the coefficient of the variable for law ranks between 5-8 is negative and so a county is less likely to have a mass shooting if it has more permissive firearm legislation.

When examining the results of a binary logistic regression, the odds ratio is the easiest to interpret. Since the odds ratio for population per mental health center is 1.000027, for every increase in the number of people per mental health center the odds of that county having a mass shooting increases 1.000027 times. This odds ratio is likely so close to 1 because of the large values in the variable. For every one percent increase in the percent unemployed, the likelihood of a mass shooting increases 1.095 times. As the percent of the population that is white increases, a county is 5% less likely to have a mass shooting.

As the Gini index value increases by one, the likelihood of a mass shooting increases 41,354.7 times. This value is large because of the very small range of the Gini values, 0-1, and so changes in the Gini index value are always less than 1. The significance of the Gini Index aligns with previous research that found income inequality contributes significantly to homicide rates (Daley, Wilson and Vasdev 2001). When the percent of housing units that are vacant increases by 1, a county becomes 7% less likely to experience a mass shooting. If a county has a law rank between 17-20, it is 1.517 times more likely to experience a mass shooting. In comparison, if a county has a law rank between 5-8, it is 30% less likely to have a mass shooting.

	Coefficient	Significance	Odds Ratio
Population Per Mental Health Center	0.000027	0.000	1.000027
Percent Unemployed	0.091	0.018	1.095
Percent White	-0.052	0.000	0.950
Gini Index	10.630	0.001	41,354.688
Percent Vacant	-0.071	0.000	0.931
Law Rank 17-20	0.417	0.176	1.517
Law Rank 5-8	-0.356	0.053	0.701

Table 6. Logistic regression analysis.

Figure 7 offers a map of counties that did not experience a mass shooting during the study period. The counties shaded with green are less likely to experience a mass shooting based on the independent variables from the regression equation. The counties that are shaded with red are more likely to experience a mass shooting. A probability less than 0.5 indicates a county is less likely to experience a mass shooting and a probability greater than 0.5 suggests it is more likely. There are 234 counties whose probability is above 0.75, placing them at an increased risk of a mass shooting. The purple counties are those that experienced a mass shooting during the study period. There is a distinct pattern in the distribution of red counties concentrated in the southeast. This area that stretches from eastern Texas across the south and up most of the east coast, has a large number of high-risk counties as well as counties that have already had a mass shooting. In contrast, within the western and Great Plains states, many of the counites are at lower risk for a mass shooting and fewer counties have already experienced one. California stands out with many counties at high risk and multiple that have already had a mass shooting. Some of these trends follow population, which has already been established as a significant factor in mass shootings.

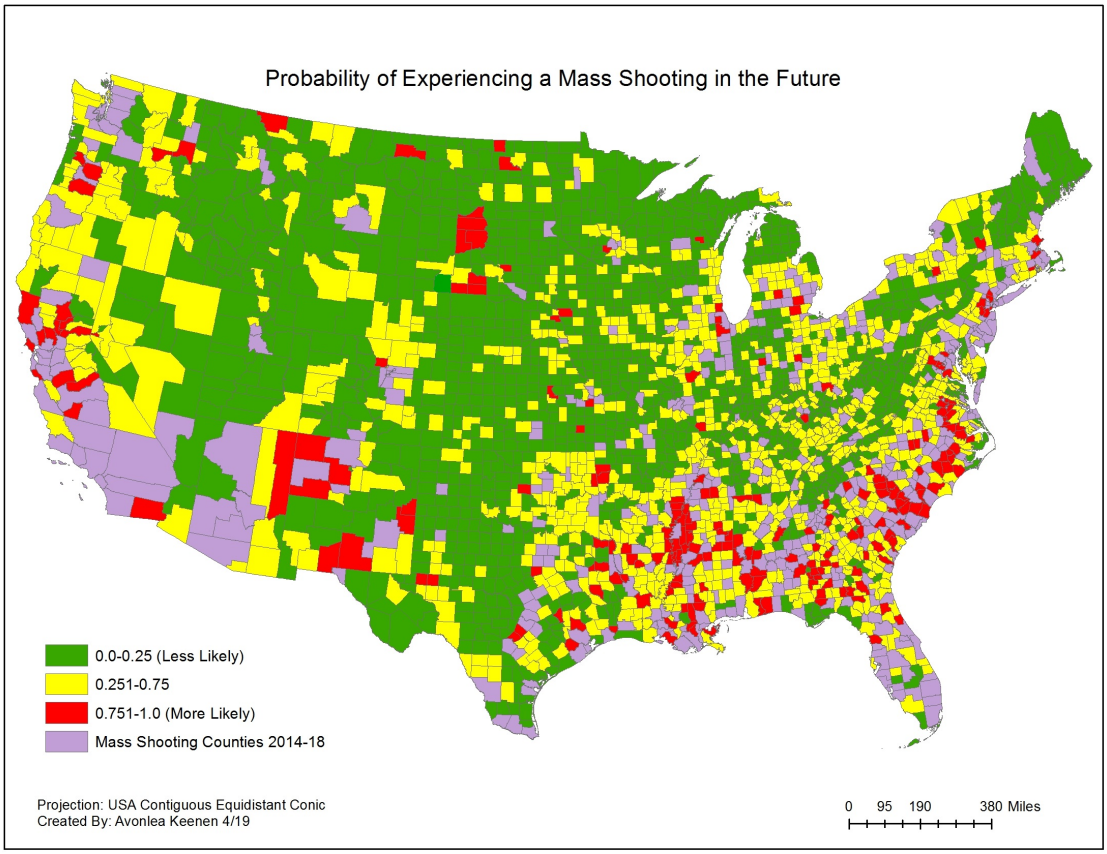

Figure 7. The probability of counties experiencing a mass shooting in the future.

CHAPTER V

CONCLUSION

Mass shootings are happening nearly every day in the U.S. and it is important to understand more about the places where they are happening. This research examined the characteristics of counties that experienced a mass shooting between 2014 and 2018. As previously noted, a typical mass shooting is not what most people think or what the media portrays (Duwe 2005). Rather, in the majority of mass shootings, just one person is killed and four injured. Between 2014 and 2018 there were 1,675 mass shootings scattered across 451 U.S. counties. In comparison to counties that have not experienced a mass shooting, these counties typically have twice as many people per mental health center and a higher percentage of the population that is unemployed. These counties also tend to have a smaller percentage of the population that is white, fewer vacant housing units, and more income inequality. This agrees with Daley, Wilson, and Vasdev's research (2001) which found that income inequality contributes to homicide rates. When compared to counties that have not had a mass shooting, there are fewer counties with permissive firearm legislation and more counties with restrictive legislation.

The first research question examined county attributes associated with locations of mass shootings. This study showed that all independent variables examined appear to influence where mass shootings occur. The population per mental health center, the percent of the population that

is white and unemployed, income inequality, and vacant housing units can be used to predict the likelihood of a mass shooting. The second research question was concerned with the influence of state firearm legislation on where mass shootings occur. After examining various firearm laws and determining which states have more restrictive or permissive legislation, patterns began to emerge.

The logistic regression equation correctly predicted whether or not a county would experience a mass shooting between 2014 and 2018, 78.8% of the time. While this is not perfect, it suggests confidence within the group of prediction variables. The regression analysis showed that as the number of people per mental health center, the percent of the population that is unemployed, and income inequality increase, the likelihood of experiencing a mass shooting also increases. As the percent of the population that is white and the percent of housing units that are vacant increase, the likelihood of a mass shooting decreases. When a state falls into the most restrictive ranks for firearm legislation, its counties are at a higher risk of mass shootings, whereas if a state has more permissive firearm legislation, its counties are at a lower risk. Using the regression equation, this study was able to determine a list of counties that have an increased probability of experiencing a mass shooting in the future (see Figure 7). Although it is certainly not guaranteed that these counties will experience a mass shooting or that those with low probabilities will not experience one, it does show which counties have risk factors.

Mass shootings are tragic events that have an incalculable impact on the people involved, therefore we need a better understanding of places where they occur. While most research has emphasized the shooter, this study has focused on identifying patterns in the locational characteristics. Although it is still important to understand the shooter's motivations, this research suggests that location characteristics may help to explain mass shootings. There are a lot of assumptions made about the causes of mass shootings and what can be done to prevent them. The argument for increased mental health access is supported by this research because an increase in

the number of people per mental health center was found to increase the risk of a mass shooting. The findings of this research suggest that the argument for more restrictive firearm laws may not reduce the likelihood of mass shootings, whereas more permissive firearm laws were found to decrease the likelihood of mass shootings. The goal for this research is to assist in understanding the true nature of mass shootings and to recognize factors that may contribute to a higher risk of such events.

SUGGESTIONS FOR FUTURE RESEARCH

There is more research that can be done to understand attributes of place and their relationship with mass shootings. One of the limitations of this study is that the firearm legislation ranks were based on state laws as of 2017. It would be useful to examine the laws at the time of each mass shooting since firearm legislation has been changing rapidly in the last decade and many new laws were passed within the study period. There are many variables that would be interesting to include in additional data analyses such as firearm possession rates, crime rates, how many people utilize mental health services, and other demographic characteristics of population. Some variables were excluded from this research because of the difficulty in acquiring data for all U.S. counties. Another potential research venture would be to incorporate an analysis of county attributes with more detailed information about the shooter and victims.

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APPENDICES

Firearm Legislation Sources

These National Rifle Association- https://www.nraila.org/gun-laws/

Campus Safety Magazine- https://www.campussafetymagazine.com/university/list-of-states-that-allow-concealed-carry-guns-on-campus/

Giffords Law Center- http://lawcenter.giffords.org/category/state-guns-in-schools/ and http://lawcenter.giffords.org/gun-laws/policy-areas/guns-in-public/open-carry/

National Conference of State Legislatures- http://www.ncsl.org/research/civil-and-criminal-justice/self-defense-and-stand-your-ground.aspx

ConcealedCarry.com- https://www.concealedcarry.com/law/constitutional-carry-and-permitless-carry-in-depth-overview/

Various state constitutions found on state government websites.

VITA

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Master of Science

Thesis: PATTERNS IN THE LOCATIONS OF US MASS SHOOTINGS

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Biographical:

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